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13. ABSTRACT (Maximum 200 words)

This supplement to an existing ONR grant was used to develop new experimental capabilities both to diagnose and manipulate single-component positron plasmas and to study the electron-positron plasma system. A technique was implemented using a CCD camera and phosphor screen to measure the magnetic-field-line-integrated density distribution of single-component positron and electron plasmas in the plane perpendicular to the field. The sensitivity is sufficient to make quantitative profile measurements on plasmas with as few as 10^7 positrons. This supplement was also used to build the apparatus for and carry out exploratory experiments to use a rotating electric field to compress single-component positron and electron plasmas.

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March 15, 1997

To: C. W. Roberson, Code 331, Office of Naval Research

From: C. M. Surko

Re: Final technical report, ONR Grant #N00014-96-1-0579

This award, in the amount of $24,970 for the period 1/1/96 to 12/31/96, was to augment our program to create positron plasmas and to use them to study a variety of physics topics including study of electron-positron plasmas.

With these funds, we purchased a new CCD camera and built the associated apparatus to directly image positron plasmas. A new insert was designed and built for the positron trap. It consisted of a specially designed phosphor screen and associated accelerating grid electrodes that are mounted on a reentrant flange complete with viewing window. The apparatus functions in the following way: Positrons are accelerated to several kilovolts and then made to impinge on the phosphor screen. The image is recorded with the CCD camera. This imaging device is able to achieve precise, quantitative measurements of the (field-line integrated) full two-dimensional distribution of positron plasmas in the plane perpendicular to the applied magnetic field. It works equally well with electron plasmas, which is relevant to our studies of the electron beam positron plasma instability.

The camera has been extremely useful. Sensitivity is excellent: plasmas of as few as 10^7 positrons can be studied quantitatively by imaging just a single shot. We have used this device to study the radial expansion of positron plasmas. It has also played a very important role in our successful effort to develop a new method to create ultra-cold positron beams. It will be (already has been, actually) a crucial addition to our efforts to study the electron-beam positron plasma instability.

Finally, the new camera has been used to collect the data necessary to better understand the operation of the present positron trap in preparation for the construction of a new generation of trapping device, now in the design stage and to be built with an ONR DURIP award.

As proposed, the funds from this expansion grant were also used to carry out experiments in a separate apparatus to study spheroidal electron plasmas. We were able to complete a set of preliminary experiments designed to compress these plasmas. This work will be important in carrying out plans to use this technique to compress positron plasmas. Our conclusion from the compression experiments is that we can now move the specially designed electrode structure developed for this work to the positron trap, and this will be done shortly.

In summary, the augmentation award has allowed us to make significant progress toward a number of goals. Perhaps more significantly, these achievements can be expected to pay important dividends in the future in our efforts to create and use positron plasmas for a number of scientific and technical purposes.

The accomplishments under this award made a significant contribution to two publications:

1. S. Gilbert, C. Kurz, R. G. Greaves and C. M. Surko, "Creation of a monoenergetic pulsed positron beam," Applied Physics Letters, to be published April 1997.

2. R. G. Greaves and C. M. Surko, "Antimatter plasmas and antihydrogen," Physics of Plasmas, to be published in the special issue, May 1997.

The CCD imaging results were presented in the invited plenary review talk by C. M. Surko at the November 1996 APS Plasma Physics Division meeting.